Pavement Management Update- Executive Summary

Lowell, Massachusetts

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Introduction

The City of Lowell, Massachusetts retained the firm of Vanasse Hangen Brustlin, Inc (VHB) in 199 9 to develop a pavement management system to assist the City in maintaining it's 230 mile roadway network and to determine necessary funding levels to maintain and improve roadway conditions. In 2008, the City hired VHB to update the system to reflect the current condition of its pavements. The pavement management system has also been upgraded to the RoadManagerGPMS™ software which operates in a GIS (map based) environment and enhances the city's ability to evaluate the road network and plan for projects.

Using the updated pavement condition data and the tools in the pavement management software, VHB has performed the following analysis of the network-wide conditions, and the predicted effects of multiple funding scenarios.

This report is intended as an update to the report delivered during the initial system implementation in 1999. A digital copy of that original report has been redelivered to the City for reference and more detail regarding pavement management concepts and process.

Methodology

The following is an abbreviated description of the steps taken in developing the pavement management system.

Pavement Management Section Identification

VHB developed a roadway network of pavement management segments. Each street contains one or more pavement management sections. A pavement management section defines the limits of previous construction or maintenance activities within each street. Sections are defined by having the same width, typical distresses, functional class, etc. The goal is to set up homogenous areas of pavement to aid in assigning the appropriate repair. A street may be one section, or it may be comprised of several pavement management sections, depending on its construction history.

Surface Distress Assessment

For each pavement management section, the severity and extent of nine major pavement distresses are recorded, then entered into a weighted formula to arrive at a Pavement Condition Index (PCI). The distresses are categorized as base related or surface related distresses. Base related distresses indicate that the subsurface soil strength is inadequate for the existing traffic load. Streets that show significant base related distresses may need to have the subsurface soils fortified with stone to strengthen the structure and/or the street may need a significantly thicker layer of pavement. Surface related distresses are caused by age and weathering of the pavement. Streets that have predominantly surface related distresses are excellent candidates for maintenance sealing to inhibit further pavement oxidization (the main effect of aging). Streets with more of the base related distresses will most likely need some full depth patching, structural overlays or reclamation/reconstruction.

The four base related distresses are:
- potholing or non-utility patching
- alligator cracking
- distortion
- rutting

The five surface related distresses are:
- block cracking
- transverse or longitudinal cracking
- bleeding or polished aggregate
- surface wear or raveling
- shoving, slippage or corrugation

PCI Defined

A PCI was generated for each inventoried pavement management section in Lowell using the surface distress data collected by VHB. PCI is measured on a scale of zero to one hundred, with one hundred representing a pavement in perfect condition and zero describing a road in impassable condition. Each type of observed pavement distress is assigned a deduct value based on the type, severity and extent of the distress.

PCI = 100 – (Highest Deduct Value) – (25% of remaining base related deduct values) – (10% of remaining surface related deduct values)

The Five Treatment Bands

VHB's RoadManager™ software uses broad ranges to group the individual repair types into five major treatment bands. Treatment bands are a useful tool to summarize data on a City-wide basis. An individual road segment will fall into a particular category based on the strategy table's output of repair types and will vary due to functional classification. The goal is to gain a broad understanding of the existing conditions in simple yet meaningful terms.

Treatment Band Descriptions

TREATMENT BAND	PCI*	Description
DO NOTHING	93-100	Excellent condition - in need of no maintenance.
ROUTINE MAINTENANCE	86-92	Good condition – may be in need of crack sealing or minor localized repair.
PREVENTIVE MAINTENANCE	73-85	Fair condition – pavement surface may be in need of surface sealing, full depth patch and/or crack sealing.
STRUCTURAL IMPROVEMENT	61-72	Deficient condition – pavement surface structure in need of added strength for existing traffic. Typical repairs are overlay with or without milling.
BASE REHABILITATION	0-60	Poor condition – in need of base improvement. Typical repairs are reclamation or full depth reconstruction.

Note: The Treatment bands are defined below and can also be referenced in the glossary of terms.

*These are only general PCI ranges for reference purposes, and represent only one pavement type. There are several fields considered by the strategy table when assigning repair types to each individual street.

Customizing Repair Strategies

VHB met with the City Engineers to review VHB's typical repair strategies, and to learn how to customize these strategies to meet the City's specific needs. VHB also refined repair unit costs. VHB's goal was to understand Lowell's decision-making process and simulate that process in the budget analysis software based on the pavement condition and other criteria of each pavement section.

Preparing Budget Scenarios

Once the roadway conditions are inventoried and analyzed, and the repair strategies are defined, the impact of various spending programs on the roadway network is assessed. These studies can range from 1 to 20 years; however, for the purpose of this report 10-year studies are used. The purpose of the budget planning process is to determine the impact of various spending levels to find a funding level that will best meet Lowell's needs. The budget module uses deterioration curves, unit costs, and the strategy tables developed in the repair strategy definition phase to assign each street a repair type and associated cost for each year of the study. The module also assigns each street a benefit value that is used to prioritize which streets the software will select for repair each year. **It is important to understand that RoadManager*GPMS*™ is a network-wide planning tool, and is not intended to give definitive street-by-street repair data. Field verification and testing are recommended to confirm any street repair list generated.**

Project Prioritization

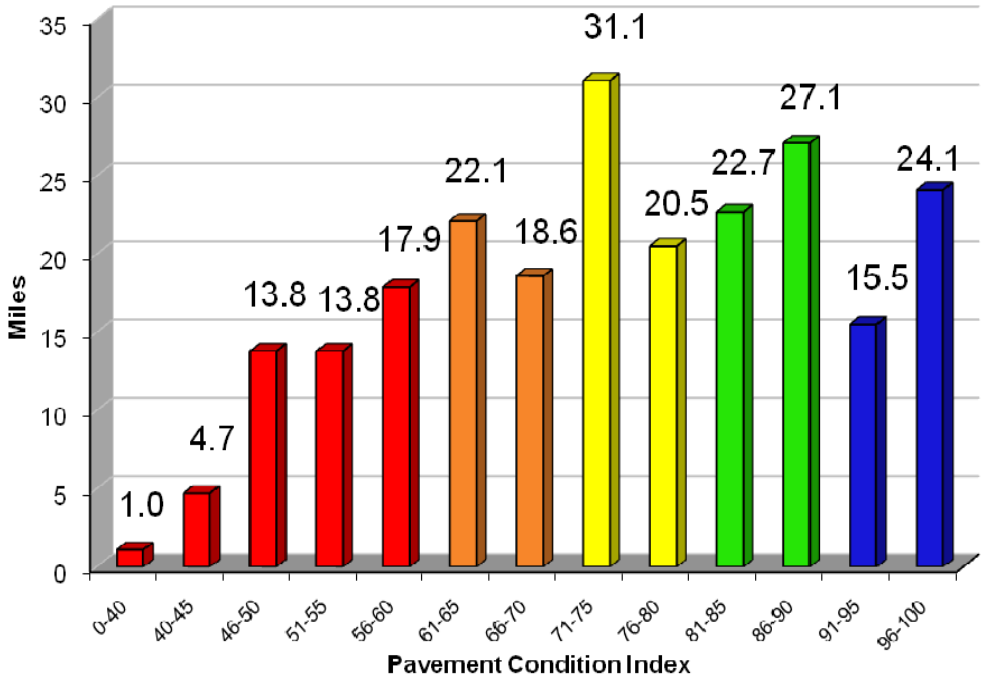
The Budget Analysis module prioritizes needed system repairs based on the estimated "Benefit Value". The Benefit Value formula is calculated using variables representing traffic volume, repair service life, PCI, and unit repair costs for each pavement management section. The calculation for the Benefit Value is shown in the Glossary at the back of the report. For each plan year, the software prepares a future roadway condition projection, exhausts the assigned budget, and then produces an annual list of roads included in the repair program. The system also allows the user to enter an inflation rate to account for estimated increases in future year construction costs. A 4% inflation rate was used for Lowell.

The Benefit Value prioritization process generally favors cost effective maintenance alternatives. Repair actions are typically delayed on those sections that require reconstruction or major rehabilitation because the benefits for dollars spent are generally lower than maintenance candidates. After the relatively good roads are "saved", improvements are directed towards the poorer arterial and collector roads, and then to the local roads in need of major rehabilitation.

Current Conditions

City Roads Pavement Conditions

VHB conducted the field evaluation of pavement conditions on 232.9 miles of roadway in 2008. During the project, VHB was made aware of a number of roads in the Southeast (Flats) area of the City that were undergoing sewer separation work, and would be paved in the next year. **The following analysis treats these roads as though they are already repaved**. The average PCI for Lowell's road network at the time of this report (April 2009) is a **74**. A PCI of 74 represents a road in fair condition that is or would soon be in need of resurfacing. The wide dispersal of conditions shown below indicates that Lowell would benefit from an aggressive maintenance program to protect roads in fair shape, while rehabilitating roads in poor condition as funding allows.



PCI Distribution

Backlog of Work

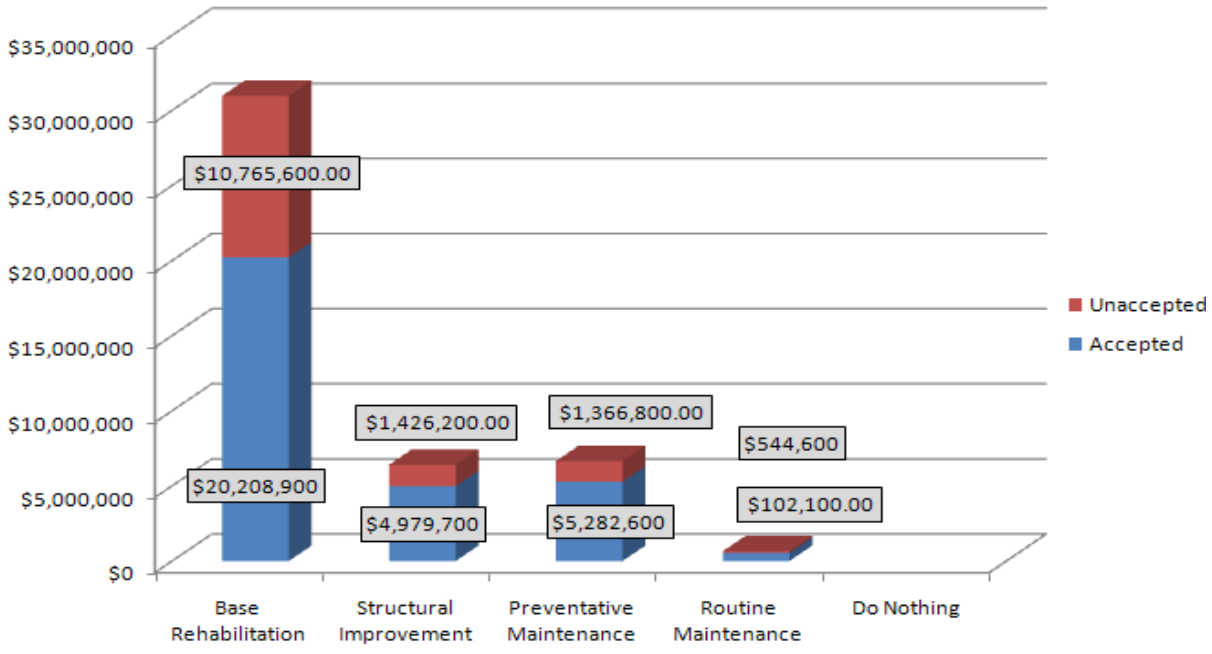
The City has 174.3 undivided miles of Public, Accepted Roads, as well as 58.6 miles of Public, Not Accepted Roads. Because the sources of funding used to repair these roads may be different, the following analysis summarizes the data for both groups of roads separately

Applying the five treatment bands shown in Table 1 and unit costs referenced in Appendix B to Lowell's road network, a summary of outstanding work was developed. The following table gives the miles and dollars associated with each treatment band for the conditions at the time of the evaluation.

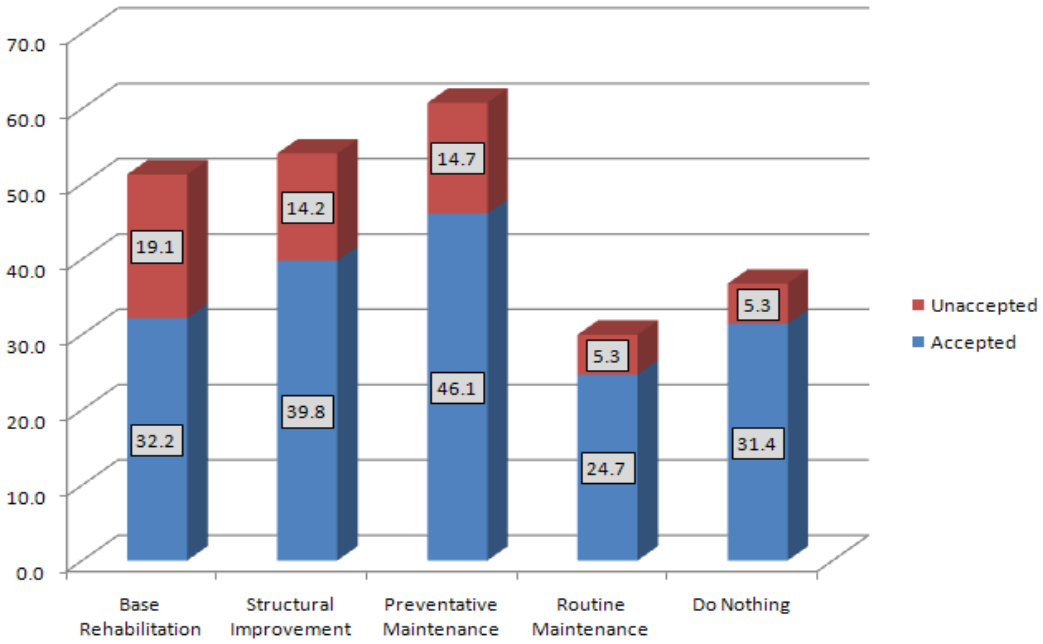
Summary of Miles and Dollars of Outstanding Work

	Cost		Miles	
Treatment Band	**Accepted**	**Unaccepted**	**Accepted**	**Unaccepted**
Base Rehabilitation	$20,208,900	$10,765,600.00	32.2	19.1
Structural Improvement	$4,979,700	$1,426,200.00	39.8	14.2
Preventative Maintenance	$5,282,600	$1,366,800.00	46.1	14.7
Routine Maintenance	$544,600	$102,100.00	24.7	5.3
Do Nothing			31.4	5.3
	$31,015,800	**$13,660,700.00**	**174.3**	**58.6**

The following two figures present the above information graphically.



Current Backlog Mileage by Treatment Band



Current Backlog Cost by Treatment Band

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GIS Map of Current Pavement Conditions

By linking the City's pavement database to a GIS roadway centerline, VHB and the City are able to create thematic maps to help in the analysis and presentation of the information within the database. The map below, which displays current pavement condition, is an example of the possible types of maps that can be generated.

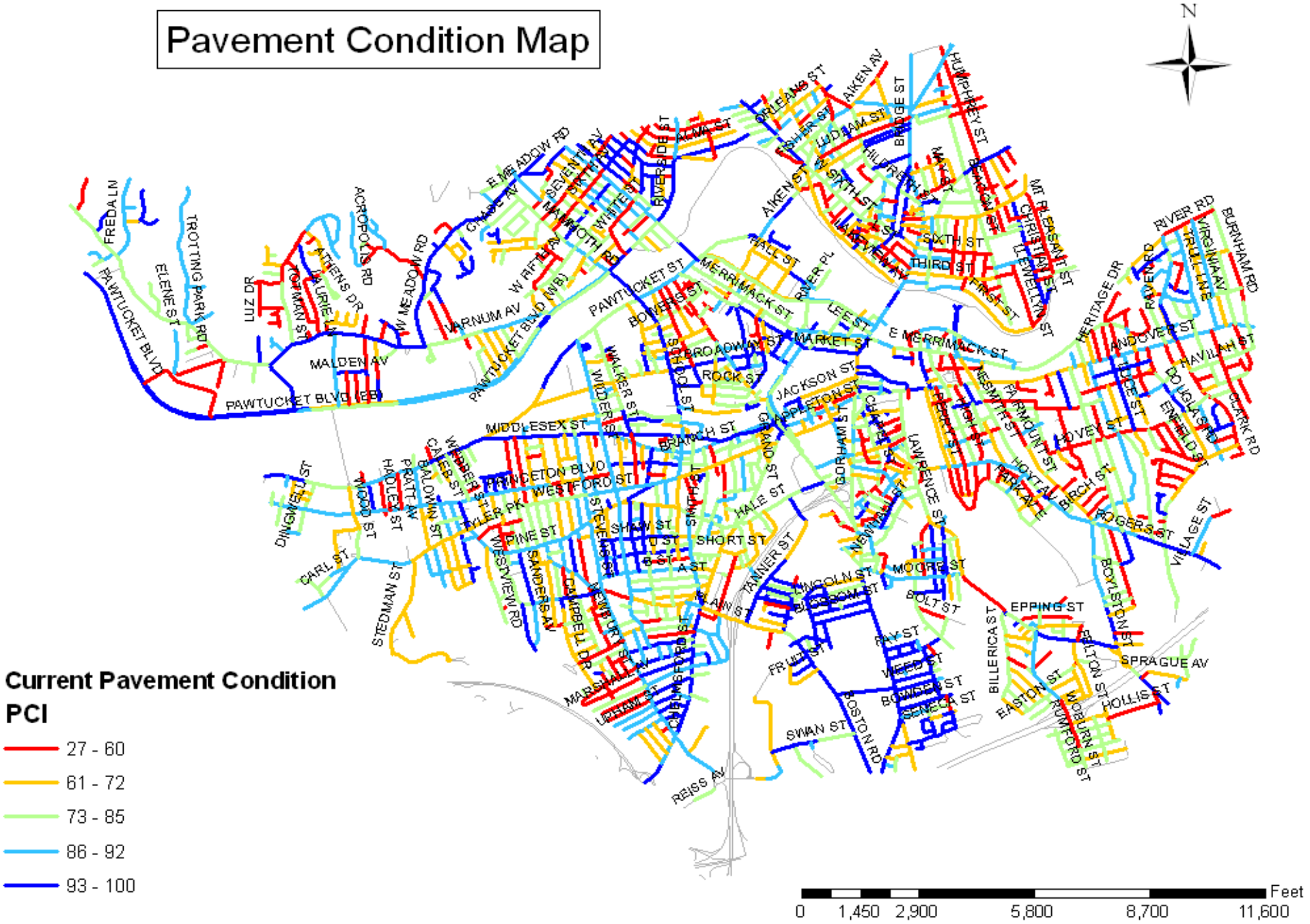


Figure 5 – City-wide Pavement Condition Map

Budget Analysis

Scenarios Explored

VHB projected the PCI and dollar backlog for four funding scenarios that accounted for all City-maintained roads. These scenarios explored the possibility of applying different levels over a period of 5 years to see how that would affect the overall pavement conditions in the network. The scenarios were run separately for Accepted and Unaccepted roads, as their funding sources are different.

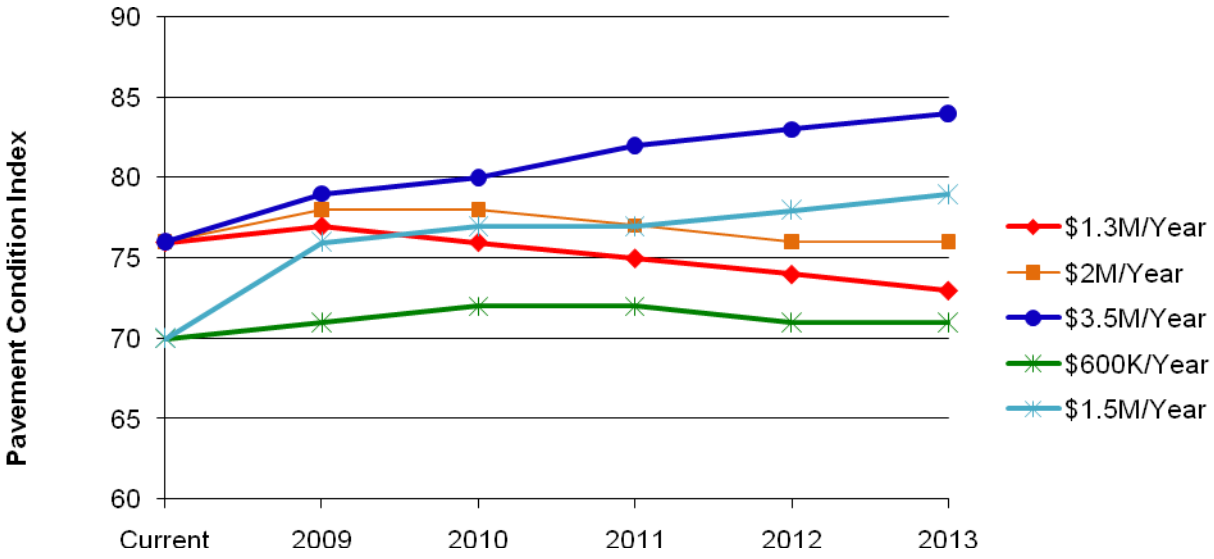
The funding scenarios examined were:

- Accepted Roads
  - $1,300,000/Year- Chapter 90 Funding
  - $2,000,000/Year- Amount Needed to maintain PCI
  - $3,500,000/Year- Amount needed to maintain dollar backlog
- Unaccepted Roads
  - $600,000/Year- Amount needed to maintain PCI
  - $1,500,000/year- Amount needed to maintain dollar Backlog

Scenario Results- Projected PCI

The following table and chart shows the trends of the City-wide pavement conditions over a 5 year period under various funding levels.

	Accepted Roads			Unaccepted Roads	
	$1.3M/Year	$2M/Year	$3.5M/Year	$600K/Year	$1.5M/Year
Current	76	76	76	70	70
2009	77	78	79	71	76
2010	76	78	80	72	77
2011	75	77	82	72	77
2012	74	76	83	71	78
2013	73	76	84	71	79



Scenario Results- Projected Dollar Backlog

The following table and chart shows the trends of the dollar backlog of pavement work over a 5 year period under various funding levels.

	Accepted Roads			Unaccepted Roads	
	$1.3M/Year	$2M/Year	$3.5M/Year	$600K/Year	$1.5M/Year
Current	$31,016,000	$31,016,000	$31,016,000	13,661,000	13,661,000
2009	$33,646,000	$33,646,000	$33,646,000	14,121,000	14,121,000
2010	$39,506,000	$37,618,000	$35,503,000	15,714,000	14,105,000
2011	$42,538,000	$39,793,000	$33,777,000	16,280,000	13,670,000
2012	$48,657,000	$44,861,000	$32,516,000	16,816,000	13,161,000
2013	$54,540,000	$48,896,000	$31,136,000	17,992,000	13,266,000